Goed vooruitzicht. Onzekerheid en het verantwoord besturen van de aarde als systeem [Good prospects. Uncertainty and the responsible governance of Earth as a system]

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Good prospects
Uncertainty and the responsible governance of Earth as a system

Arthur Petersen, September 29th, 2011

This text is an English translation of Professor Arthur C. Petersen's inaugural address as Special Professor of Science and Environmental Public Policy at the VU University Amsterdam, held at September 29th, 2011. This chair was created by the PBL Netherlands Environmental Assessment Agency and addresses the large, deep uncertainty associated with the dynamics of the Earth system and the dynamics of societies. How can societies and individual actors deal with uncertainty and complexity? The overarching question is: how, in the face of all the many uncertainties, can system Earth be managed in a responsible manner? More specifically, how can scientists form good prospects of the future – while telling like it is – without being condemned as false prophets?

Arthur Petersen (1970) obtained PhD degrees in atmospheric physics and chemistry (Utrecht University, 1999) and in philosophy of science (VU University Amsterdam, 2006). He now works as Chief Scientist at the PBL Netherlands Environmental Assessment Agency and as Special Professor of Science and Environmental Public Policy at the VU University Amsterdam. He is Visiting Professor at the London School of Economics and Political Science and Research Affiliate at the Massachusetts Institute of Technology.

After his dissertation in philosophy of science, on uncertainty in computer simulations of climate change, Arthur continued researching topics in methodology and modelling. He published on methodological aspects of the Intergovernmental Panel on Climate Change, the statistics of climate change in the past and on the value-ladenness of model assumptions. He also performed social-scientific research into (methods for) responsibly dealing with uncertainty and has published on 'post-normal science', stakeholder participation in scientific assessments, dealing with value plurality, adaptive policy-making and dealing with uncertain technological risks.

Besides his professional jobs, Arthur has been active within Pugwash (or Pugwash Conferences on Science and World Affairs in full), an organisation that brings together, from around the world, influential scholars and public figures concerned with reducing the danger of armed conflict and seeking cooperative solutions for global problems such as those related to poverty alleviation and protection of the environment.

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Rector Magnificus, ladies and gentlemen,

Prophecies are rarely fulfilled, although this does not deter the prophets and their followers. Throughout history, many cults have told us that the end of the world is nigh, and they look forward to the ensuing 'ecstasy'. In their view, the world is a bad place and must be put out of its misery. They believe that they will be spared, and in preparation they live their earthly lives in accordance with their particular interpretation of the Kingdom of God. Even when their latest prediction of the end of the world fails to materialize, they continue to insist that they are right and that they are indeed 'the chosen ones'.[1] Prophets who unconditionally predict the end of the world are *false* prophets. A theologian might tell us that a *true* prophet is someone who tries to awaken mankind, to alert us to certain risks. A true prophecy is thus not the same as a prediction.[2]

Can the environmentalist who predict the end of the world due to global warming also be regarded as false prophets? They are entirely convinced that they are right, but are they also blind to the facts? Since the publication of his book *The Skeptical Environmentalist* in 2001, the Danish sociologist Bjørn Lomborg has attracted considerable international publicity. He accuses environmental organizations of being selective in their presentation of scientific data in order to support the standpoint – or 'litany' as he terms it – that the world is in terminal decline.[3] One similarity between some environmentalists and the aforementioned cults is that they adhere to a very slanted interpretation of the facts: all life on Earth will come to an end and it is already far too late to do anything about it. One difference is that their predictions of environmental catastrophe have a somewhat more distant horizon, whereupon it will be many decades or even centuries before all the facts are known and we can determine whether there is any sound basis to those predictions. And then we have the false prophets who claim that there is no such thing as climate change caused by human activity. They too predict the end of the world as we know it, but one brought about by draconian environmental legislation. A question which has occupied me for many years is how science can help policy to steer a course between these two extremes – the alarmist position and that of the denialists.

Today, there is indeed great uncertainty about the future of our planet. For one thing, we still know too little about how the Earth works as a system. We are dealing with an extremely complex natural system, and one which we shall probably never completely understand. This applies at all levels of scale, from the local to the global. We are now in the *anthropocene,* an era in which mankind itself has become a significant geological factor, with human activities having a major impact on the Earth's ecosystems. The large-scale changes to 'system Earth' can create new opportunities as well as new risks. Both the opportunities and the risks are subject to uncertainties. Indeed, the future is shrouded in uncertainty. Not only do we not know how the natural systems work, we do not know nearly enough about how society itself works at any level of scale. Furthermore, the measures proposed in response to the risks created by system changes will themselves have uncertain effects.

In short, climate change might result in many species becoming extinct, and in the complete collapse of human and natural systems. On the other hand, the consequences could be relatively minor. (The operative word here is 'relatively', since there will still be a dramatic local impact in some places, and of course disastrous consequences for the species which are lost.) Similarly, the measures and new technologies which are now seen as promising ways to mitigate the damage may indeed be real breakthroughs, but they could all come to nothing. How should society and the individual actors address the many uncertainties? What approaches are available to them? Within the limited time at my disposal today, I shall try to explain how such questions can be made the subject of formal research.

My research revolves around a broad interpretation of 'uncertainty', in which there is also a place for ambiguity and the complexity of objectives. It allows for various world views and values. But there remains one key, overarching question: how, in the face of all the many uncertainties, can system Earth be managed in a responsible manner? More specifically, how can scientists form good prospects of the future – while telling like it is – without being condemned as false prophets? I address such questions in the context of 'the good life': a philosophical concept which can be summarized as a pleasant and responsible existence for everyone, retaining everything good that our planet has to offer for the benefit of both today's society and future generations.[4]

The precautionary culture

In the past, people took a very different approach to uncertainty and risk.[5] In early modern society, those who suffered harm (in the sense of injury, loss or damage) were not seen as 'victims' to be helped or compensated. They and they alone had to bear the consequences: a case of 'every man for himself'. Any misfortune, such as an accident in the workplace, was attributed to fate. The nineteenth century saw a shift from the 'blame culture' to a 'risk culture', in which loss or injury was seen more as an inevitable system effect rather than the avoidable consequence of individual actions or omissions. From the viewpoint of costs versus benefits, people would simply accept the risks, while collective arrangements – insurance – provided compensation for any loss or injury incurred. It was in the 1970s that the 'precautionary' culture began to emerge.

Roel Pieterman, who specializes in the sociology of law, explains the precautionary culture as the result of five societal learning processes, together with a radicalization of the risk culture.[6] The first such learning process was the development of the welfare state, which taught everyone that an increasing number of different types of 'harm' would be compensated, and compensated more fully. Second, many of the existing threats to health and wellbeing had now been removed. Third, people were encouraged to believe that the prevention of loss or damage was not their own direct personal responsibility. Fourth, it was realized that many risks and threats go beyond the individual's direct personal experience or sphere of influence. And fifth, there was far greater scepticism with regard to the authority of government. I would like to add a sixth process to this list: a shift from an emphasis on solidarity to an emphasis on self-interest.

The combination of these factors led to a call for all risks to be eradicated. Alongside the risks created by climate change further to human activity, Pieterman discusses – at the same level – the risks of low-frequency radiation from mobile telephone networks, the risks of drilling for gas under the Wadden Sea, and the risks of vaccinating children. Mobile network operators wishing to erect new antennas still face significant public opposition, even though experts state that the risks are negligible or non-existent. Permits to extract gas from under the Wadden Sea have been withheld on numerous occasions. There is a significant body of research to confirm that the risks (predominantly the risk of subsidence) are minimal. Nevertheless, permit procedures were delayed due to the uncertainty that remained. And while there is worldwide consensus that the health gains of vaccination far outweigh the risks, there are still parents who refuse to have their children vaccinated, citing hypothetical damage to the immune system, the development of ultra-resistant virus strains or the extremely small risk – less than one in a million – of a fatal reaction.

A precautionary climate policy?

In my view, it is not appropriate to place the risks of climate change due to human activity on the same level as these technological risks. The cited examples are all small risks, although exactly how small is itself uncertain. There is evidence to suggest that the global climate has changed significantly over the past century. It is 'very likely', by which I mean that there is a greater than 90% probability, that the average global surface temperature rose by between 0.6° and 0.9°C during this period.[7] If we look at even longer timescales, we see evidence of significant warming. The past fifty years have 'likely' (greater than 66% probability) been the warmest period in the northern hemisphere for the past 1,300 years.[8] The past one hundred years have seen a significant increase in rainfall in the eastern parts of North and South America, northern Europe and North and Central Asia. There have been equally significant droughts in the Sahel region, the Mediterranean region, southern Africa and parts of South Asia.[9] In most land regions, periods of heavy rainfall have become more frequent.[10] Let us remember that the variability of weather conditions is also part of the concept of 'climate'.

Of course, such statements about observed climate changes say nothing about the causes of those changes. Nevertheless, the vast majority of climate scientists believe that there is a link with the 'greenhouse effect' which is enhanced by human activity. The link has even been quantified. It is 'very likely' that at least half of the warming seen during the past fifty years is attributable to man's emissions of greenhouse gases.[11]

Given all the changes observed, and given the fact that at least some can be attributed to the greenhouse effect of human activity, it is not unreasonable to assume that even greater changes are in store. Some of the future changes to our climate system are already inevitable, having been caused by past emissions. Even if global emissions of greenhouse gases are vastly reduced in the very near future, these changes will still occur. Take, for example, the rising sea levels. During the course of the twentieth century, the average sea level worldwide rose by between 12 and 22 cm. It is very likely that this was due in part to expansion caused by higher water temperatures.[12] Moreover, it seems probable that sea levels will continue to rise for hundreds, perhaps even thousands of years, whereupon the overall increase will be in the order of several metres. It will, after all, take hundreds or thousands of years before the temperature of all oceans rises by an equal amount.

But even in the somewhat shorter term – within the next one hundred years, we are likely to see some dramatic and unavoidable effects of climate change. It is perfectly conceivable that the small island states (such as the Maldives) will face ever more frequent and ever more destructive flooding. The same applies to the low-lying coastal zones of the continental land masses – regions in which hundreds of millions of people now live. Bangladesh is one example. There might also be changes in the patterns of precipitation, while the higher temperatures will place considerable strain on various ecosystems. Some of those ecosystems may not survive, whereupon many species of flora and fauna face extinction. We are already in a desperate situation. No matter what we do, we are powerless to halt some climate changes, and hence unable to preclude the problems they will cause. In the interests of balance, I should also mention that some countries – such as Russia – will actually benefit from climate change, provided it is not too extreme, in that their agricultural output will increase. So, the effects are not all negative.[13]

We should not attach too much value to the precise outcomes of modelling forecasts, however. The fundamental debate about climate change must focus on the seemingly improbable events which will nevertheless have major consequences should they occur. It is still too early to say whether the 'precautionary culture' has provided an effective response to the climate problem. In terms of climate policy, the precautionary principle[14] offers very little assistance in making appropriate decisions. Just how cautious must we be? Must we strive to restrict global warming to 2°C? Could we permit ourselves a little more leeway, or is 1.5°C already too much? How much must national governments and other actors invest in the necessary measures? The precautionary principle does not provide the answers to such questions. In fact, in the context of the climate treaties, the precautionary principle merely allows countries to implement a policy while there is still remaining uncertainty. It can do no more. To put it another way, the precautionary principle encourages us to insure against the possible collapse of system Earth, but does not allow us to calculate the maximum permissible 'premium'. This is a source of great concern to many economists.

Cost-benefit analysis

What role could cost-benefit analysis play in evaluating measures designed to optimize opportunities and restrict the risks to man and nature in the face of a possible collapse of system Earth? Let us first consider how Lomborg suggests we should proceed. He proposes establishing different spending priorities for the resources we now devote to international development. Lomborg assembled a group of eight leading economists (including three Nobel laureates) in Copenhagen to prioritize proposals for ways in which to tackle various world problems, ranging from the HIV/Aids pandemic to the Kyoto Protocol and taxes on carbon emissions. The experts were asked to assume that governments had a ‘spare’ fifty billion dollars at their disposal. In this group’s ranking of the ten most pressing global problems, climate change finished in tenth place.[15] For the past few years, Lomborg has been the director of the Copenhagen Consensus Center, part of the Copenhagen Business School, where he has repeated this process.

The critical question which we can ask Lomborg and his colleagues is whether the standard cost-benefit analysis is really able to establish such a ranking. Can it do so in a manner which is politically acceptable and which adequately addresses the very long timescales of system Earth, as well as the requirement for continuity or ‘sustainability’? Where sustainability relates to the allocation of relatively scarce natural resources, there is of course an economic aspect at play. In any analysis of the sustainability issues, it is therefore useful to draw upon formal welfare theory.[16] That theory is concerned with subjective economic goals which are defined more broadly than the objective economic goals (wealth in terms of the possession of economic assets) or financial economic goals (wealth in terms of money). Given that the pursuit of one goal will often stand in the way of achieving the other, concessions and compromises must be made at both the individual and societal level.[17] To use the formal term, there will be ‘trade-offs’.

Many uncertainties attach to the use of cost-benefit analyses at the level of system Earth.[18] Applying the standard economic discount rate does not allow us to compare the future effects on welfare with the immediate effects. And when evaluating measures, should we be concerned solely with the overall returns or should we also take the fair distribution of the welfare effects into account? What factors should determine the discount rate itself? What valuation methods should be used? Can the chosen method address the negative valuation of possible catastrophes? Given uncertainties such as these, the question is whether the amount that represents the effects of the measure on the ‘balance sheet’ is merely the result of an arbitrary calculation. If so, it is meaningless. It is certainly useful to assess policy proposals in terms of their likely effectiveness, and to take account of the priorities which global society wishes to pursue. However, this ‘means discussion’ must not obscure the ‘goals discussion’. If the climate risks identified today are considered unacceptable, mankind must take action but must do so in a way which does not create unacceptable consequences in terms of other world problems. Now that there is a collective objective – to limit global warming to within two degrees and to do so with a reasonably certain degree of probability – it is indeed useful to apply a cost-benefit analysis to the various proposed solutions and to apply economic policy instruments. But we should remain alert to the perversities which may emerge, as in carbon emissions trading systems which could result in additional loss of biodiversity.

Nuclear energy and geo-engineering?

The discussion about the economic efficiency of ‘solutions’ to one of the greatest threats to system Earth – the climate problem – is closely linked to the discussion about technology. What new technologies will actually materialize and which will work? Opinions are divided. There are those who propose a technological ‘quick fix’, and others who regard this option as highly undesirable. Among the latter group there are those who do not wish to use technology at all, and those who are willing to experiment, but to do so cautiously taking the uncertainty factor fully into account.

There are many different forms of technology which could be applied. Many environmental scientists consider it a matter of course that we must eventually derive practically all our energy from renewable sources such as solar and wind power. Exactly how these energy technologies will have developed by 2050 and beyond is unknown: this is yet another uncertainty. We can make plans and projections based on the technologies we already have, but we must also take into account the possibility of new technologies being developed in the meantime. Given the scale and seriousness of the problem, however, the world cannot afford the luxury of dismissing any energy technology out of hand. All options – including nuclear energy and even 'geo-engineering'– must be given due consideration. Of course, both nuclear energy and geo-engineering are subject to a number of caveats and misgivings which will do much to inform the societal debate in the years to come. My decision to devote attention to nuclear energy and geo-engineering today could, I suppose, be interpreted as a call to consider these options in preference to solar and wind energy. That is a risk I shall have to take, but it is really not my intention. In fact, I think we may be expecting rather too much of nuclear energy and geo-engineering.

Nuclear energy does indeed serve to reduce carbon emissions and, according to many experts, is economically attractive even when all the social costs and other negative aspects are taken into consideration. Nevertheless, investment in nuclear energy is currently at a very low level, with many projects having been abandoned or put on hold following the Fukushima disaster. Current uranium stocks will certainly last the rest of the 21st century without the nuclear industry having to resort to enrichment or recycling. But even with a major upscaling of current nuclear energy facilities, this option would eventually be able to provide only some ten per cent of the global energy requirement. Nuclear energy can therefore never be regarded as the sole answer to climate change. Moreover, some major disadvantages attach to the use of nuclear energy and to any upscaling. Apart from the problem of disposing of nuclear waste safely, which has still not been solved, the proliferation of nuclear weapons must be a major concern. It seems that our world is unable to observe the doctrine of the non-proliferation treaties. There are several countries which have used the development of nuclear energy as a stepping stone to that of nuclear weapons. And if Fukushima has taught us anything, it is that there are always aspects that not even the most diligent safety planner could have foreseen. Being well prepared means remaining open to surprises – a point to which I shall return in a few moments.[19]

Geo-engineering comes in many shapes and sizes. One proposal is to launch gigantic mirrors into space to deflect the sun's rays. This is not a particularly practical idea. Other suggestions include injecting a fine mist of sulphate particles into the stratosphere, or 'seeding' seawater to promote evaporation and the formation of cloud cover – both somewhat more realistic. Even planting new forests can be seen as a form of geo-engineering, the intention being that the trees will absorb carbon from the atmosphere. The geo-engineering methods which deflect sunlight are being touted as a form of 'emergency cooling' for our planet. People used to be concerned that too much attention was being devoted to reducing greenhouse emissions and to climate adaptation. Today, they are concerned that the technological geo-engineering options will merely 'camouflage' the effects of the greenhouse gases. Once again, the problem would not be tackled at its source. Many options, such as injecting sulphate particles into the stratosphere, are not permanent solutions. Once you stop injecting the particles, the underlying problem – the increased CO_2 concentration – is actually worse than it was and the warming effect will continue even more rapidly. This sort of geo-engineering – also known as 'solar radiation management' is at best a stopgap option to offset the worst effects of rising temperatures, while extremely stringent emission reduction measures will have to be implemented as a structural solution for the long term. Another objection to most geo-engineering options is, of course, their unknown and uncertain risks.[20]

Institutional questions

In all discussions about solutions to the climate problem, whether in the economic sphere (carbon pricing and trading) or the technological, it is essential to remain realistic about which measures should be implemented at which level. Moreover, it must be asked whether the global community is actually capable of making agreements which will limit the temperature increase to below two degrees, given the enormous economic interests which attach to CO_2 emissions and their reduction. The international negotiations thus far give little cause for optimism. According to David Victor, professor of International Relations at UC San Diego, the architecture of the UN negotiation process is not fit for purpose. There are too many countries at the table and too many topics on the agenda.[21] He suggests that there should be a 'carbon club' in the mould of the earlier world trade negotiations, with only those countries which really matter in terms of carbon emissions taking part. Rather than making agreements on reduction targets and timeframes – which are actually rather meaningless because it is extremely difficult for governments in countries with an open economy to manage or control emissions at all – they should make agreements regarding the actions to be taken by national governments.[22] Victor also proposes that membership of this 'pioneer group' should bring certain specific benefits so that other countries will wish to join, and will become eligible to do so only if they endorse 'climate accession agreements'. In this scenario, the UN will come to the fore only at a much later stage, embracing the (by now) extensive group of countries which have already linked their respective emissions trading systems, and promoting the development of a truly global regime. That regime is then the culmination of the process, not the starting point of the negotiations. Whether Victor's proposal is viable remains to be seen. It seems unlikely that Europe would find it acceptable. Nevertheless, it does seem appropriate to treat the climate problem not as the exclusive domain of the United Nations, but to leave the door open for other forums which can play a useful part in tackling it. In any event, Victor makes specific reference to the economic aspect of climate policy, which does of course play a dominant role.

Although the current formula for a reduction in greenhouse gas emissions is familiar to all concerned – a stable and adequately high carbon price together with policy to promote energy efficiency and the development of new energy technologies with low carbon emissions – the actual implementation of this formula is far from easy. Governments are unable to predict or manage societal developments, and neither can they predict or manage technological developments. The difficulties need come as no surprise. Even during the 1990s, the social scientists drew attention to the likely problems, as in the assessment *Human Choice and Climate Change,*[23] co-authored by Steve Rayner, now a professor at Oxford University following an extensive career in the United States. This assessment presents valuable insights into framing, institutional processes, the speed of social change, the limitations of rational planning, interdisciplinarity, the focus on practice, 'mainstreaming', implementation at the regional and local scale, resilience and the pluralistic approach to decision-making.

The very same aspects have once again come to the fore in recent years. A good example is the interdisciplinary project *De Matrix* which, under the leadership of Dirk Sijmons, has set out to identify cohesive action opportunities for climate and spatial policy in the Netherlands.[24] The project calls for a climate mitigation policy to be implemented at the international level, with a direct 'trickle-down' effect for companies and the general public in all countries, whereby national governments play no more – and no less – than a facilitating role. In the wake of the Copenhagen Climate Conference fiasco, Albert Cath, who represents the social sciences within the project, published an interesting article in the national newspaper *De Volkskrant*, the title of which can be translated as 'The ball is in the citizen's court after Copenhagen'.[25] In the economic sphere, Sander de Bruyn has proposed a new form of CO_2 levy on all products, operating in a similar way to value added tax. This 'Gross Added Carbon Tax' would bring the costs of climate policy directly to the level of the individual consumer.[26] Eric Ferguson and I have called for a levy on every oil and gas well, and on every coal mine.[27] Both latter proposals serve to plug the various loopholes which allow the unscrupulous to circumvent the current emissions trading system. Both, I would contend, deserve further research, to include a careful examination of the institutional aspects. In the field of spatial policy, Bram van de Klundert states that the attainment of the emission reduction targets, and/or the removal of carbon from the atmosphere, represents a challenge of potentially mammoth proportions. He therefore suggests that it is extremely important to research whether it will be possible to achieve a cultural shift in the Netherlands, replacing the NIMBY (Not In My Back Yard) attitude with one of '*Please* in My Back Yard' (PIMBY).[28] How can the advantages of sustainable energy sources be passed on to the (local) producers of sustainable energy? Once again, the national government's role should be that of facilitator, whereby the main effect will be achieved in the context of a strong international policy.

In a similar vein, Maarten Hajer, director of the PBL Netherlands Environmental Assessment Agency, has recently proposed a radical change in the government's management philosophy.[29] At present, he contends, the government makes too little use of the creativity and learning ability of the business community and the general public. While there remains a clear role for the government in promoting a broad portfolio of technological development,[30] it is now time to involve the 'soft' institutional side as well. By removing obstacles and barriers, the government will encourage society at large to play its part in developing new markets for the new technologies.

In short, institutional questions play a very prominent role in any response to the climate problem, which is one of the most significant issues affecting the continuity and sustainability of the Earth system. I am extremely proud that VU University, and specifically Frank Biermann, have taken such a leading role in the worldwide Earth System Governance project, which highlights the crucial importance of institutional changes to the global decision-making system. I am also extremely proud that the project has asked me to co-chair its 'Taskforce on Methodology for Earth System Governance Research'. One thing is already very clear to me: the current international approach to Earth system governance is unsatisfactory. We need new institutions and a radical shift in how to deal with knowledge and values. This is what I shall be working to achieve in the years to come.

Uncertainty, complexity and guiding principles

What makes the responsible governance of the Earth as a system so very difficult? I would like to offer a very brief account of the complexity and uncertainty which characterize the problems involved. Nature and mankind – the world itself – are extremely ambiguous. Looking for the *essence* of nature, of man or of the world is a fruitless task.[31] We term a situation or idea 'ambiguous' if it can be viewed from two or more frames of reference, each of which is consistent in itself but incompatible with the others. In the traditional scientific approach, the participative mode must be suppressed, and we must act as if everything is external, objective and immutable. One of the most basic aspects of the state of humanity – of being a person – is that our conscious selves can work in one of two different modes at any one time: that of actor or that of observer. The alternative, propounded as a new scientific approach by the mathematician William Byers among others, is to allow yourself to be aware of the ambiguity of situations, and to translate that ambiguity into creativity.

Examples of ambiguity within mathematics include the polarities of quality and quantity in whole numbers, and the complex world of real numbers, which can be treated as both discrete and continuous.[32] The French philosopher, sociologist and 'complexity thinker' Edgar Morin developed a system theory based on evolutionary biology. Here too, there is an irreconcilable ambiguity between subject and object.[33] Human behaviour can often be modelled – to a certain extent – based on the options available within the existing structures, but there always remains a grey area in the form of unpredictability and surprises. We thus see *reflexivity*, whereby the relationship between the options and structures is not stable. In his book

Ignorance and Surprise, the German environmental sociologist Matthias Gross offers an overview of sociological theories which have given rise to social experiments and surprises.[34] Gross concludes that much of the current sociological theory relating to our knowledge society is based on deep uncertainty and the inevitability of surprises. He cites the regeneration of the open-pit brown coal mines south of Leipzig to become an attractive lakeland area as an example of a social experiment. Very little was known about how to go about transforming these deep pits, from which all water had been assiduously pumped out in the past, into lakes of ecological value. However, because all actors were determined to bring about the transformation, they were prepared to allow for surprises and to adapt their plans and methods accordingly without too many institutional problems. They were able to learn 'on the fly'.

In such an unpredictable, complex world, how can we hope to achieve the 'good prospects' of my title? Let me first call upon one of the greatest thinkers of our age, Amartya Sen. At the beginning of his book *The Idea of Justice,* Sen proposes a theory of justice which can and, he contends, *must* be applied in practice, It is one which offers the opportunity to determine how injustice can be reduced in order to promote justice.[35] He therefore opts not to present the largely irrelevant characteristics of the perfect and perfectly just society, upon which so much political philosophy is based. To arrive at a responsible governance system for the Earth itself, we must arrive at a theory which defines justice in the sense of a 'good life in partnership with the Earth'. That theory must establish the factors which will promote such a just relationship and those which would undermine it, without presenting any idealistic, Utopian picture. In short, it must be a *pragmatic* theory. Such a theory will not seek optimization, but will identify the worst case scenarios and strive to mitigate their effects should they indeed emerge.

Next, I turn to the aforementioned Edgar Morin, who in the 1990s applied his thinking on complexity to the global environment problem and its implications in terms of the responsibilities of mankind in the anthropocene era.[36] Morin concluded that man's task is to continue the process of civilizing the Earth. Amid the hopelessness of late-modern society, which incorporates both problem and solution, we must encourage the evolution of modernity through a process of experimentation. Morin formulated six basic principles for this task, here shortened to aphorisms:

1. Life builds up hope that builds up life.
2. All the great transformations or creations have been unthinkable until they actually came to pass.
3. All the happy events of history have always been a priori improbable.
4. First, dig underground and transform the substratum before anything is changed on the surface.
5. Where danger threatens, that which saves from it also grows.
6. We can become even more human.

There is no guaranteed 'happy ending' here, but at least there are reasonably good prospects. After all, we are only just at the very beginning of the anthropocene. But even in the worst case scenario, I believe that the observance of the following guiding principles, inspired by Morin's aphorisms, will enable us to make use of new technology in our governance of the Earth system:

1. Do not be a false prophet, but continue to hope that man and nature will continue to live on Earth. Working to develop new technology will offer hope.
2. Allow for the possibility of new technological breakthroughs and behaviour which could not have been foreseen.
3. Do not stake everything on technological developments which experts consider feasible at a given moment. They may not materialize.

4. Allow new technology to prove itself gradually by means of small-scale local experiments. If and when critical mass is achieved, the technology can then be incorporated into the system as a whole.
5. Be alert to the risks of new technology: its use can both exacerbate and mitigate problems.
6. Learn from one's mistakes in order to be able to use new technology more effectively.

These are, of course, just examples of the possible guiding principles. In the years ahead, I shall attempt to formulate yet more based on empirical research. I shall study social experiments in which one learns how to cope more effectively with uncertainty, ambiguity and complexity. I shall also examine various value systems, the effect of institutional conditions, and the way in which scientists and policy-makers regard their own roles. In all this, my frame of reference will be that of philosophical pragmatism. My heuristics will be the experiment: what constitutes a good social experiment? My metaphor will be Morin's analogy of digging down into the substrata. My compass will be the ethics of 'the good life'. In all my research, I shall apply a practical 'down to earth' approach in examining the various aspects of the development of new technologies: safer nuclear generators, geo-engineering and renewable energy, to cite just three examples. Once again, I wish to stress that effective solutions to the problems which jeopardize the future of the Earth system will rely on the existing methods, such as carbon pricing, just as much as on any new technology. New approaches must not represent a technology push: there must be a technology *pull*.

The role of scientists

Given all the uncertainties which surround the future of the Earth system, what role can and should scientists play in the societal debate about its governance? The perceptions of risks such as climate change are ambiguous and vary between countries, cultures and communities. Even scientists hold varying perceptions of the risks, although they do not always make those perceptions explicit. When a scientist is called upon to advise the government or to take part in the public debate, he bears a great responsibility to perform the task well. To explain this point further, it is useful to consider the various roles which scientists can play in relation to the decision-makers.

In his book *The Honest Broker* (2007), Roger Pielke identifies four possible roles. The first is that of 'pure scientist'. In this role, the scientist is not interested in the practical implications of his or her research, but is merely searching for 'the truth'. The second role is that of 'science arbiter', in which the scientist will confine himself to advising on those issues which can be incontrovertibly resolved by science: there are right answers and wrong answers. The third role is that of 'issue advocate'. Here, the scientist attempts to promote a particular interest by virtue of his status as an expert, while not revealing his own values or preferences. Finally, there is the 'honest broker of policy alternatives'. This role comes to the fore when the problems under consideration are too complex and too politically polarized to permit any straightforward, hard-and-fast scientific advice to be given.

In today's climate debate, we can see scientists playing each of these four roles. Given the complexity and conflicting interests inherent in climate policy, it is the 'honest broker' who can claim to address the facts most effectively, doing so with due regard for the values involved. But is it possible to fulfil this role with complete effectiveness? In the media, we regularly encounter issue advocates at the two extremes – those for climate measures and those against – who base arguments on their own slanted interpretation of the uncertainties. One is absolutely convinced that doom and disaster await, the other is equally convinced that there is nothing to worry about. Each takes a very different approach to the underlying scientific knowledge. Within their own groups, there is after all a significant degree of selectivity when it comes to the facts which matter. It is not possible to offer any straightforward recipe whereby we can resolve the deadlock. It is certainly inappropriate to return to a hard division between facts and values.

In 2009 and 2010, the sceptics used the media to engineer ‘Climategate’. Based on emails and other documents obtained by hacking the computers of the University of East Anglia’s Climate Research Unit, they claimed that the data on global temperatures hundreds or thousands of years ago had been falsified. The advocates of climate policy refuted the allegations. Ultimately, this discussion is about the functioning of the scientific community, and especially the role of peer review, when a research programme involves such significant societal interests. Once it is realized, as Latour and Woolgar reminded us over thirty years ago, that all science is conducted by people, who may be expected to have the typical human failings, and that many ‘facts’ are actually historical constructs, the accusations of ‘foul play’ will quickly follow.[37] And yet, there are epistemic and non-epistemic values at play in all scientific practices. Together, those values create a subjective component, or ‘value-ladenness’, in the data, models, theories, apparatus, routines, disciplines, etc. By adopting a perspective from which all scientific results are regarded as historical constructs, it is possible to expose the value-ladenness of scientific communities. A meta-analysis of ‘Climategate’ from such a perspective provides a deeper understanding of how scientists collectively prepare themselves to participate in a thorny controversy. Those scientists can be seen to devote considerable attention to methodology, by the way.[38]

I would like to propose a fifth role for scientists. It can be seen as an extension of the role of ‘honest broker of policy alternatives’ but has a somewhat broader scope. This role entails revealing and explaining precisely what the scientific field is doing. It entails providing transparency with regard to the questions raised, and it entails reflection on the science system itself. I therefore term this role the ‘reflector’ The reflector will reflect upon how research themes are defined; he will reveal and explain the underlying value patterns. The reflector attempts to stand above the process of interaction between the physical world and policy. He is not concerned with the possible answers to policy questions. Rather, he is interested in whether the right questions have been asked, and what must be done if there are several, potentially conflicting, interests at stake. In a complex society, how can one do justice to the interests of the people of today, while also taking seriously the scientific ‘worst case analyses’ which relate to the effects on future generations?

Lastly, I wish to call for greater interaction between those people who hold very different visions, whether of climate change or of science itself. The concept and tools of ‘post-normal science’ – an interactive method of providing decision-makers with scientific information which has been reviewed by a more extended community of peers – would seem to offer very promising opportunities in this regard.[39]

To arrive at a complete list of ten guiding principles, I will add four more, which I base on my earlier research:

7. Take ‘normal science’ seriously, but also organize reflection on its uncertainties and value-ladenness.
8. Alongside the *statistical* reliability of results (expressed in terms of probability), devote due attention to their *methodological* reliability (expressed in terms of strengths and weaknesses) and their *public* reliability (expressed as the degree of public confidence in the scientists who produce them).
9. Involve a larger group of specialists and non-specialists who hold different values in monitoring the quality of scientific assessments.
10. Be wary of accepting the conclusions of actors and practitioners at face value: try to delve deeper through the layers of complexity by means of narrative methods.

In the years ahead, I also expect to conduct further research in this methodological area, specifically, the methodology of organizing interaction between science and policy.

Acknowledgements

Before I conclude, I would like to take this opportunity of acknowledging my gratitude to various people who have played a key role in my work and career to date.

First, allow me to thank the Rector Magnificus, the members of the university's Executive Board and the Dean of the Faculty of Earth and Life Sciences for the confidence you have shown in confirming my appointment to the chair of Science and Environmental Public Policy. I also wish to thank the directors of the PBL Netherlands Environmental Assessment Agency – Maarten Hajer and Reinier van den Berg – and their predecessors Klaas van Egmond and Fred Langeweg, for having endowed the chair and for my nomination as its incumbent. It is a privilege for me to work one day a week at VU University, alongside my work as Chief Scientist at the PBL Netherlands Environmental Assessment Agency and as the Deputy Head of its Department of Information, Data and Methodology. I certainly have a marvellous job, not least thanks to my sterling colleagues. It gives me great satisfaction to work alongside them on assessments which are not only of high scientific quality but of great relevance to policy.

I already feel 'at home' here at VU University. Together with Eleftheria Vasileiadou, I lead the 'Science and Values for Environmental Governance' research group, part of the department of Environmental Policy Analysis led by Frank Biermann. The research group and department form part of the Institute for Environmental Studies (IVM) and the Amsterdam Global Change Institute (AGCI), both of which are led by Frans Berkhout. I have been working with the IVM for several years – and with much pleasure – on two projects: 'Modelling Governance and Institutions for Global Sustainability Politics' (ModelGIGS) and 'Bridging the Gap between Stakeholders and Climate Modellers'. The latter is a joint project involving the PBL, VU University and the Royal Netherlands Meteorological Institute (KNMI). I am very much looking forward to further cooperation with colleagues from both VU University and the University of Amsterdam within the new Amsterdam Global Change Institute, and no doubt with colleagues from other universities and institutes. I derive great fulfilment from working alongside PhD students, postdoctoral researchers and senior researchers at VU University, the University of Amsterdam, MIT, the London School of Economics, Utrecht University, Wageningen University, the Open University, the PBL, the KNMI and the National Institute for Public Health and the Environment (RIVM). Together we perform truly groundbreaking research and we have some very ambitious plans; I hope we are given the opportunity to bring those plans to fruition!

It would be impossible for me to thank everyone who is involved in these projects, but I do wish to mention Frans Berkhout, Frank Biermann, Ken Oye, Larry McCray, Lenny Smith, Eleftheria Vasileiadou, Erik Min, Wilco Hazeleger, Dave Huitema, Philipp Pattberg, Marcel Kok, Joyeeta Gupta, Matthijs Hisschemöller, Joske Bunders, Jan Boersema, Joop de Boer, Annick de Witt, Hanna Schösler, Stefania Munaretto, Gabriella Doci, Ayşem Mert, Eva Kunseler, Willemijn Tuinstra, Pita Spruijt, Anne Knol, Erik Lebret, Arjen Zegwaard, Flip Wester, Daniel Hogendoorn, David Laws, Anne Loeber, Maarten Hajer, Albert Faber, Albert Cath and Mieke van Hemert. No doubt this list will become longer as time goes on.

This is also an appropriate moment to thank those who have contributed to my personal development as a scientist. That process began during my MSc project in Theoretical Physics, which was supervised by my VU University colleague Piet Mulders. He oversaw my research into the scattering of neutrinos off carbon nuclei, and it was due to his invitation to join the NIKHEF group in the early 1990s that I gained my first experience in working as part of a tight-knit research team. During the same period, Hans Radder and Peter Kirschenmann, also

of VU University, inspired me to take up research into philosophy of science. They also supervised my second dissertation, which I successfully defended some ten years later.

During my first doctoral research project, it was Han van Dop, Bert Holtslag, Jos Lelieveld and other colleagues at the Institute for Marine and Atmospheric research Utrecht (IMAU) and the KNMI who taught me how to perform research into atmospheric science. I look back with great pleasure on the eighteen months I spent sharing an office with Pier Siebesma and Harm Jonker at the KNMI. Inspired by ideas suggested by Peter Duynkerke of IMAU, I undertook my first serious research in boundary layer meteorology. The resulting article, published in the *Journal of the Atmospheric Sciences* in 1999, remains my most-cited work. It has even been used in research examining solar convection. I thank all my colleagues at the IMAU and the KNMI for their help and support.

Between 1999 and 2001, I enjoyed a period of reflection as a postdoc/PhD researcher at the Faculty of Philosophy at VU University. I wish to thank the faculty, and in particular Hans Radder, for giving me the opportunity to study the reliability of the very computer simulations which I had been using for the previous four years. Alongside the philosophical insights I gained from Hans Radder and Peter Kirschenmann, I was able to broaden my horizon yet further by becoming involved in the national graduate school Science, Technology and Modern Culture (WTMC). In my current position, I hope that I will be able to make some contribution to the further development of Science and Technology Studies.

In the spring of 2001, I saw my dream job advertised in the newspaper. The environmental assessment division of the RIVM was looking for a senior researcher to examine the societal aspects of uncertainty. I applied and was accepted. I remain extremely grateful to Anton van der Giessen, Peter Janssen and Fred Langeweg for having given me the opportunity to work on methods to address ‘uncertainties’, including social-scientific methods. In 2003 I was appointed project and programme manager. For the past 10 years I have been concerned with finding ways to ensure and enhance the quality of the assessment agency’s products. Following the merger with the Netherlands Institute for Spatial Research in 2008, I have been doing so under the auspices of the PBL Netherlands Environmental Assessment Agency. I would like to thank my fellow methodologists there, Arthur Beusen, Anton van der Giessen, Maria Hage, Peter Janssen, Bram van de Klundert, Johan Melse, Sido Mylius, Willemijn Tuinstra, Hans Visser, Martine de Vos, Bert de Vries and Bert de Wit. I also wish to thank Marjolein van Asselt of Maastricht University, Arjan Wardekker, Penny Boneschansker-Klopprogge and Jeroen van der Sluijs of Utrecht University, Annick de Vries, Willem Halffman and Rob Hoppe of the University of Twente, and Esther Turnhout and Pieter Leroy of Radboud University Nijmegen. I must not forget Leo Meyer, from whom I have learned so much about the IPCC. Last year, Leo and I went through the IPCC report in great detail. Recently, I succeeded him as PBL representative on the Dutch IPCC delegation.

In recent years, I have become affiliated with a growing number of universities. In 2008, I was invited to join the Massachusetts Institute of Technology, where I have worked alongside Ken Oye and Larry McCray. Since 2009, I have also held a position at the London School of Economics and Political Science, where I mainly work alongside Lenny Smith. This year, I have become a Special Professor at VU University and have been appointed Chief Scientist at the PBL, a role which demands a strong connection with the academic world if it is to be filled successfully.

Finally, I would like to thank my family and friends, without whom my work would simply not be worthwhile. Let us continue to celebrate life together!

Thank you for your attention.

Notes

[1] A famous book by the social psychologists Festinger, Riecken & Schachter (1956, revised 1964) tells of the American UFO cult which predicted a flood which would destroy the entire world. Their timing was precise: the event would take place just before dawn on 21 December 1954.
[2] It was my publisher Freek van der Steen (a theologian) who drew my attention to this distinction.
[3] Based on his own presentation of a large body of statistics, Lomborg concludes that there are more reasons for optimism than for pessimism. Many ecologists have responded angrily to Lomborg's publication, accusing him of a lack of scientific integrity. An official commission reached much the same conclusion but its ruling was quashed by the Danish government due to procedural mistakes. Closer examination of Lomborg's chapter on climate change reveals that he does indeed present the main conclusions of the IPCC reports accurately, but also criticizes those findings in a somewhat dismissive and optimistic manner. I do not believe that it is just to accuse Lomborg of any impropriety based on the content of this chapter, although it is necessary to take his remarks with more than a pinch of salt. But this applies equally to some – but not all, or even most – of the statements made by the environmental activists.
[4] Cf. van de Klundert (2008), p. 3.
[5] This historical outline is taken from Pieterman (2008).
[6] Cf. Beck (1992).
[7] IPCC (2007), p. 5.
[8] IPCC (2007), p. 9. In making this statement, the IPCC authors have made allowance for the methodological problem that some trees, particularly in the northern latitudes and mountainous regions, have adapted over the course of the decades and are no longer so sensitive to changes in temperature. Accordingly, temperature reconstructions based on the 'proxy calibration' method based on tree-ring data will not reveal any significant rise in temperature since the mid-20th century, although we can be reasonably certain that such a rise has indeed occurred. This discrepancy is termed the 'divergence problem' and is examined in the scientific literature. In my opinion, the analysis of this methodological problem and the possible impact on reconstructions of temperatures several centuries in the past should be given greater attention by the scientific community than is currently the case. (See also Visser *et al.* 2010).
[9] IPCC (2007), p. 7.
[10] IPCC (2007), p. 8.
[11] IPCC (2007), p. 10. Petersen (2006, 2011) offers a thorough analysis of how the IPCC arrives at such assessments.
[12] IPCC (2007), p. 7.
[13] The PBL (2010) has demonstrated that the summaries of the 2007 report are subject to a high degree of selectivity with regard to the focus on the main negative effects of climate change. This is due to the adoption of a 'risk-oriented' approach, an approach which has itself not been adequately defined or explained in the report.
[14] The UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) offers the following working definition of the precautionary principle:
"When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm.
Morally unacceptable harm refers to harm to humans or the environment that is:

- threatening to human life or health, or
- serious and effectively irreversible, or
- inequitable to present or future generations, or
- imposed without adequate consideration of the human rights of those affected.

The judgement of *plausibility* should be grounded in scientific analysis. Analysis should be ongoing so that chosen actions are subject to review. *Uncertainty* may apply to, but need not be limited to, causality or the bounds of the possible harm. *Actions* are interventions that are undertaken before harm occurs that seek to avoid or diminish the harm. Actions should be chosen that are proportional to the seriousness of the potential harm, with consideration of their positive and negative consequences, and with an assessment of the moral implications of both action and inaction. The choice of action should be the result of a participatory process."
The Precautionary Principle, p. 13; UNESCO/COMEST (2005), http://unesdoc.unesco.org/images/0013/001395/139578e.pdf, retrieved 9 Sept 2011.
[15] Lomborg (2004).

[16] As Lionel Robbins, one of the founders of the theory, wrote: "Economics is the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses" (1935).
[17] Societal preferences which relate to the distribution of wealth can be interpreted as part of the formal concept of welfare. Similarly, the wish to ensure continuity of ecological, economic and social qualities can be regarded as a primary social requirement (whereby such continuity becomes a component of the quality of life). See: den Butter & Dietz (2004) and de Vries & Petersen (2009).
[18] With thanks to Ruth Giesen, a philosophy student at the University of Groningen who completed her internship with the PBL in 2007/2008.
[19] van Asselt *et al.* (2010, pp. 119–133) offers an account of how futurologists can address discontinuities and surprises.
[20] Frans Brom (2011) raises an interesting question: why is the initial reaction to the risks of geo-engineering so often one of caution? Insofar as geo-engineering seeks to restore a situation which has been disrupted or disturbed (the global temperature), it is indeed a form of environmental protection (which includes an element of precautionary action). However, it will not be effective if implemented too cautiously. Brom contends that the notion of precaution is based on 'an implicit idea of ecological values which have not yet been spoilt, or an environment which has not yet been damaged' (p. 13).
[21] Victor (2011).
[22] E.g. agreements covering such aspects as efficiency, technology and emissions trading systems.
[23] Rayner & Malone (1998).
[24] See www.klimaatmatrix.nl. I represented climate science in this project. The other 'intendants' were Albert Cath (social sciences), Bram van de Klundert (spatial planning) and Sander de Bruyn (economics). Some parts of this address are taken from my Matrix essay (Petersen 2010).
[25] *De burger is aan zet na Kopenhagen,* De Volkskrant, 22 December 2009, p. 11.
[26] Trouw, 23 February 2010, p. 28.
[27] Trouw, 3 November 2009, p. 28.
[28] See www.klimaatmatrix.nl.
[29] Hajer (2011).
[30] Also acknowledged by Victor (2011).
[31] The discussion of 'ambiguity' is based on Byers (2011).
[32] Byers (2011).
[33] Morin (2008).
[34] Gross (2010).
[35] Sen (2009), p. ix.
[36] Morin & Kern (1999).
[37] Latour & Woolgar (1979).
[38] Ryghaug & Skjølsvold (2010).
[39] See Funtowicz & Ravetz (1993), Van der Sluijs *et al.* (2008) and Petersen *et al.* (2011).

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